

## REPORT OF THE SECTION ON *ECOLOGY OF HARMFUL ALGAL BLOOMS IN THE NORTH PACIFIC*

The Section on *Ecology of Harmful Algal Blooms in the North Pacific* (HAB-S) met from 9:00 to 18:00 h on October 26, 2009, in Jeju, Korea. The meeting was attended by 19 members and observers (*HAB-S Endnote 1*). HAB-S was represented by all PICES member countries. The proposed agenda for the meeting was reviewed and approved by the Section (*HAB-S Endnote 2*). Co-Chairman, Dr. Vera Trainer, gave a brief history of the origins of HAB-S and reviewed the Section's Terms of Reference.

### AGENDA ITEM 3

#### Country reports

##### *Canada*

No report was available. Dr. Trainer strongly urged Canada to provide country reports in the future.

##### *China*

Dr. Mingyuan Zhu reported that eutrophication in China is mostly found in the Yangtze River estuary where the major pollutants are phosphate and DIN. The highest concentration of DIN was measured at Shanghai. The Yangtze River also discharges large amounts of nutrients, COD and oil, but in 2008 there was not as much nutrient discharge. HABs are found in the coastal regions of China; 68 HAB events were reported in 2008, affecting 13,000 km<sup>2</sup>. Events are on the increase in the Yellow Sea, and the East China Sea has largest scale and 70% of total events. The HABs include *Thalassiosira*, *Skeletonema*, *Chaetoceros* sp., and *Prorocentrum* sp. *Prorocentrum* is main species found in the East China Sea, blooming every year since 2000. *Noctiluca* sp. blooms were found in June. HAB events decreased overall, but increased slightly in the Yellow Sea. Although there has been a general increase in HAB events since the 1980s, over the last 5 years HAB events have generally had a slight decrease. The East China Sea, which has been impacted the most by HAB events, has seen an increase over a 10-year period. May to September is the season for HABs. A movement to the north of *Karenia mikimotoi* has occurred over a 5- to 10-year period. Since 2000 most blooms have been dominated by dinoflagellates.

Dr. Zhu also discussed macroalgae blooms that occurred in the Yellow Sea in 2008 and 2009. A green tide occurred in Qiangdao 2 months before it was to host the regatta at the 2008 Olympics. One million tons of the macroalgae were physically removed before the event. In May 2008, small patches were observed off the coasts of Yancheng and Lianyungang, and 10 days later significantly expanded northward towards Qingdao, reaching the coast by the end of June. The source of the green tide remained speculative but investigation showed that *Enteromorpha* sp. was the cause of the bloom, although *Ulva* sp. was implicated as well, as the algae was found attached to ropes of aquaculture facilities. The Qingdao region was surveyed in the winter of 2008–2009, but very few patches were observed, so potentially it was not the source. The survey revealed that no patches were found before April 6, 2009, but after this date a floating biomass estimated at 1.35 tons was formed. By mid-April it increased, reaching about 40 tons by the end of the month. In early May it increased to 760 tons and moved to offshore. In late May the biomass increased to an estimated 116,000 tons and moved northward. By early June it increased to 175,000 tons, and in early July reached 262,000 tons and began moving north. In 2009, the algae didn't effect many coastal areas, most of it just sinking to bottom offshore. It is thought that environmental factors, such as rising air and sea temperatures, contribute to the bloom. Scientists are still not sure where the bloom originates, or what can be done to mitigate the green tides.

Dr. John Keesing (CSIRO) presented a report on “*Recurrent large-scale macroalgal blooms in the Yellow Sea*”. In late June 2008, a green tide composed of *Enteromorpha* formed in the Yellow Sea off China. The algae is not a toxic species but it has a large economic impact to tourism and on the cost of cleaning it up. Ten

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thousand people were involved in cleaning up of 1 million tons of the algae which covered 600 km<sup>2</sup> in Jiaozhou Bay, Qingdao. The cause was initially thought to be due to eutrophication, but bloom was novel event while eutrophication is not. In 2009 a linkage was found between *Porphyra* cultivation and *Enteromorpha* biomass accumulation. A recommendation has been made to modify the way rafts are cleaned to dispose of *Enteromorpha* on land. There also needs to be a better understanding of *Enteromorpha* biomass accumulation on rafts and in the sea.

### Japan

Dr. Shigeru Itakura reported that paralytic shellfish poisoning (PSP) and diarrhetic shellfish poisoning (DSP) in 2008 and 2009 were caused by *Chattonella antiqua*. In 2008 total PSP events overall were lower than in the previous 8 years, mainly in the JP04 and JP02 areas, and DSP occurrences were moderate. In Ariake Bay, southwestern Japan, the average depth is 20 m, with a range in tides of 5 m, a broad tidal flat. A *Chattonella* red tide occurred there in August 2000. A cyst survey conducted found dense concentrations of cysts. In 2009, another bloom occurred at the head of bay from July 17–23, then moved to the mouth of bay from July 24–31 during which there were strong winds from north and heavy rainfall which resulted in very low salinity and *Porphyra*. At the mouth of bay, finfish aquaculture sustained damage during that year.

### Korea

Dr. Yang Soon Kang's HAB case report for 2008 and 2009 was given by Co-Chairman, Dr. Hak-Gyoon Kim. No fisheries damages were reported in 2008 and 2009 (the largest fishery damage occurred in 1995), but *Cochlodinium polykrikoides* blooms were present in 2008. The species bloom started in Kamak Bay and lasted from July 30 to September 29, 2008. Small-scale blooms took place in 2008 due to very low rainfall, low nutrient levels and strong feeding pressure by zooplankton. No blooms of *C. polykrikoides* occurred in 2009 due to very high precipitation in July, which drove the salinity down. However, there was a *Chattonella* bloom on west coast from July 14 to 21, but no fish were killed. August and September were the peak months for HAB events in 2008 and 2009. Other HAB species blooms are *Alexandrium* sp., *Scrippsiella* sp., and *Gonyaulax* sp. In 2009 precipitation in July was very high, driving salinity down.

### Russia

Dr. Tatiana Orlova reported that most HAB monitoring on Russian pacific coast is being conducted in Peter the Great Bay. A total of 28 bloom-forming species, mostly diatoms, were detected in 2009. Among them were potential DSP, ASP, PSP producers. July and August were the months when DSP was most prevalent. June to autumn is when amnesic shellfish poisoning (ASP) is common, although *Pseudo-nitzschia australis* is not one of the factors. During monitoring for epiphytes and benthic species, *Osterois ovata* and *Siamensis* sp. were found, (typically tropical species), with concentrations up to 1460 cells/g of wet weight. HAB resting stages and cysts are also monitored. *P. multiseriis* was shown to increase in toxicity in culture, possibly because of the change of bacteria composition of *Alteromonas*, shown to increase domoic acid (DA) production from previously low producer of DA (*P. multiseriis*). The ELISA method used for DA detection showed that *P. pungens* and *P. calliantha* produced DA from Russian waters. ASP toxin was found in 96% of total samples (mollusks) ~60% for DSPs. A larger span time for monitoring has now been given because of the results from mollusks. PSP toxins have been detected as well in sediments and *Alexandrium tamarense* cells and cysts are present in the Kamchatka region. Mycotoxins (aflatoxins) are also measured in scallops and fungi (B1, G1, G2 toxins), with values 0.38–1.03 µg/kg.

### U.S.A.

Dr. Trainer noted that in Alaska, Washington, Oregon and California, only PSP and ASP testing is done. No red tides are reported. No DSP testing is done, so fish killing toxins generally do not get reported. In Alaska in 2009, there were frequent PSP closures, but rarely ASP closures; 2008 saw many PSP closures, and no ASP closures. DA was detected in harbor seals. An Alaska phytoplankton monitoring program was started in 2008 by the University of Alaska in collaboration shellfish growers and volunteers who are trained to ID and test for toxins.

Washington State has mussel sentinel monitoring stations. Closures due to PSPs are frequent and common in Puget Sound, but are few on the coast. The Puget Sound Sound Toxins monitoring network for HAB cell detection is an early warning system that is made up of growers and volunteers who sample, identify and communicate the results to fish and shellfish farmers in the region and to the State. The first closures for DA in Puget Sound took place in 2005. DSP toxins found throughout Washington recently, but no monitoring program for these toxins has been set up yet. In 2009 there were no closures on the outer coast for ASP toxins. Closures on the coast for PSP were rare but concentrations were high, reaching 405 µg/100g. a Pacific Northwest Harmful Algal Blooms Forecasting Bulletin is a web-based information system that provides a comprehensive early warning information, such as winds, currents, upwelling index, cell abundance, drifters, river discharge, and weather for potential development of Washington coast HAB events. For example, an *Akashiwo sanguinea* bloom this year resulted in sea bird deaths, and the HAB Bulletin gave a risk level of red (high) during this occurrence.

In Oregon there were PSP closures in bays along coast: DA closures, if any, were in the northern coastal region. In 2008 there were no DA closures. However, there is an annual stoppage of digging from May to October, regardless of monitoring results. Oregon issues weekly reports on HABs and toxins in its MOCHA (Monitoring the Oregon Coast for Harmful Algae) program.

California reported 2008 levels of PSP above 80 µg/100g. The State conducts an annual quarantine from May to October. There were no DA closures. Weekly biotoxin reports are made, giving abundance information on phytoplankton, including HABs.

#### AGENDA ITEM 4

##### **FUTURE science program**

Dr. John Stein, Science Board Chairman, informed HAB-S of PICES' new integrative science program, FUTURE (Forecasting and Understanding Trends, Uncertainty and Responses of North Pacific Marine Ecosystems). FUTURE is made up of three Advisory Panels on Climate, Ocean Variability and Ecosystems (COVE), Anthropogenic Influences on Coastal Ecosystems (AICE) and Status, Outlooks, Forecasts and Engagements (SOFE) who will play a role in providing advice on the priorities of FUTURE, including reviewing proposed expert groups in relation to FUTURE activities and recommending activities to be undertaken by existing expert groups. A joint meeting of the FUTURE Advisory Panels would be taking place on October 27 to, in part, to discuss working with existing PICES expert groups, and Dr. Stein encouraged the Section to attend.

#### AGENDA ITEM 5

##### **Relations with international organizations**

##### *ICES*

Dr. Donald Anderson (WHOI) gave a report on the ICES-IOC Working Group on Harmful Algal Bloom Dynamics (WGHABD), its background and method of doing science and discussed potential collaboration between WGHABD and PICES expert groups. WGHABD meets for 3–4 days during the ICES ASC and discusses HAEDAT maps, member country reports, and new findings (i.e., *Azadinium* is the causative organism of azasporacid toxins). (Dr. Anderson suggested that HAB-S do new findings instead of focusing on a demonstration/meeting (cysts, raphidophytes, etc.). It was suggested that HAB-S could undertake both new findings as well as lab demonstrations, since the latter is valuable to participants for the training aspect and transfer of knowledge.) WGHABD also reviews their Terms of Reference at each meeting and discusses specific topics and items that need to be done, such as new species, data collation, map generation, research report generation, etc. Special workshops and meetings are then organized separately on specific targeted topics and special reports produced. Dr. Anderson presented HAB-S with a number of opportunities to collaborate with ICES including:

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- HAIS/HAEDAT submissions,
- workshops or intercalibration exercises,
- joint participation in special sessions,
- coop research reports on specific topics,
- exchange of “new findings” summaries.

HAB-S reviewed the suggestions and concluded that:

1. joint meetings with ICES might not be possible because of size restraints and time of year conflicts with the PICES Annual Meeting;
2. it might be possible for WGHABD member to attend a PICES workshop and *vice versa* for a HAB-S member, and that the member would make a summary report from the workshop;
3. more discussion was needed in HAB-S to decide what types of collaborations it wanted to undertake with ICES;
4. HAB-S should probably require PICES member countries to turn in written reports for their countries, not just slide presentations; HAB-S also discussed establishing a form sheet for each country to fill out.

### *NOWPAP CEARAC*

Dr. Takafumi Yoshida (NOWPAP) informed HAB-S that NOWPAP has established a HAB Integrated Website to provide HAB-related information in the NOWPAP CEARAC region ([http://www.cearac-project.org/HAB\\_Integrated\\_Website/](http://www.cearac-project.org/HAB_Integrated_Website/)). The website includes links to:

- Publications – reports on HABs from working groups, national reports (Korea, Japan, Korea, Russia), special publications, case studies reports, other outputs;
- Database – HAB reference database (searchable), case studies, and HAB expert database;
- Topics – *Cochlodinium*, satellite remote sensing, and eutrophication events.

There were no limitations to sharing data through the PICES and ICES database systems.

### *IPHAB/IODE Task Team on the development of the Harmful Algal Information System (HAIS)*

Dr. Monica Lion (IOC) provided an update on the joint work of the IPHAB/IODE Task Team on the development of the Harmful Algal Information System (HAIS). The objectives of such a database is to serve such groups as managers, scientists, policy administrators. The establishment of HAIS builds on the evolution over the past 15 years of a number of separate databases and products that have been developed in partnership between IOC, ICES, PICES and ISSHA. When HAIS is in place, users will have access to taxonomy, references and an expert directory; monitoring and management design with ICES (MONDAT); interface with Encyclopedia of Life. The Task Team is presently looking for funding to implement the plan.

## AGENDA ITEM 6

### **PICES Seafood Safety Project**

Dr. Charles Trick presented an update on the PICES Seafood Safety Project which began in 2007 with funding assistance from the Ministry of Agriculture, Forestry and Fisheries of Japan (MAFF). The purpose of the project is to build capabilities in non-PICES member countries in the Pacific Rim to monitor and test for HAB species and toxins for seafood safety. A tiered monitoring strategy is used – analysis of phytoplankton, then, if warranted, toxin content in phytoplankton and finally, if warranted, toxin content of shellfish. Efficiency and cost effectiveness is key to the project and is specific to each region. The first training class was held in the Philippines from January 15–23, 2009 and the agenda included rapid testing for toxin screening (ELISA, Jellet), database organization, phytoplankton identification and monitoring, coordination of data collection and submission. The criteria for selecting the next country of focus is that it be geographically distinct from the previous one; it have existing HAB problems resulting in fisheries losses; it have its government support of management needs; it have the potential for sustainable monitoring. Guatemala was visited in September 2009 to identify the level of training needed, and to discuss with managers and fishers what the HAB problems

were. It was noted that many of Guatemala's red tides were not health issues for human consumption, so fish farmers may be more open to having testing done.

#### AGENDA ITEM 7

##### **GEOHAB Ocean Science Meeting on “HABs and eutrophication”**

Dr. William Cochlan reported on the GEOHAB 2<sup>nd</sup> Open Science Meeting on “HABs and eutrophication” held in Beijing, China, on October 18–21, 2009. It was particularly appropriate that this meeting was held in China, as the rate of nutrient loading to coastal waters in China has increased rapidly over the past several decades with the rapid industrialization of this country, and eutrophication-related HAB events are now common along the Chinese coast. The meeting featured seven keynote presentations, ranging from reviews of the rapidly expanding HAB events and their impacts throughout Chinese waters in the past, to global estimates of the expanding distribution and impacts of *Nocticula scintillans*, to nutrient discharge from expanding aquaculture operations and their impacts. Participants also heard local reviews of eutrophication-related HAB events. Contributed talks described a broad range of topics, underscoring many aspects of the complexity of the relationships of HABs with nutrients. Unintentional message that eutrophication causes HABs, and thus can be controlled through control of nutrients, is not true for many areas. To further the dialogue and the sharing of information on this important topic, a special issue of the Chinese Journal of Oceanology and Limnology is being prepared to capture the highlights of this meeting.

#### AGENDA ITEM 8

##### **Ex-officio membership in HAB-S**

The Executive Secretary of PICES, Dr. Alexander Bychkov informed HAB-S that scientific issues that PICES deals with are not limited to the North Pacific. Therefore, Council has looked for a legal framework to bring in experts from outside of PICES member countries to contribute and exchange scientific information at PICES standing committee and expert group meetings. Dr. Bychkov encouraged HAB-S to consider recommending an expert from an organization or program that the Section has relations with for *ex-officio* member status.

#### AGENDA ITEM 9

##### **Workshops and meetings at PICES-2010**

Proposals for meetings and workshops:

- A 1-day HAB-S meeting, including country reports for HAB events in 2007–2008 and discussion of HAEDAT use. Countries are requested to input HAB event data to HAEDAT for 2005–2006 directly to the online database;
- A 1-day Workshop and lab demo on the “*New technologies and methods in HAB detection I. HAB species detection*” co-convened by Dr. Ichiro Imai (Japan) and Dr. Vera Trainer (U.S.A.) (*HAB-S Endnote 3*);
- A ½-day Topic Session on “*Conceptual and numerical models of HAB dynamics*”, organized by Dr. Shigeru Itakura (Japan) and Dr. William Cochlan (U.S.A.) (*HAB-S Endnote 4*).

#### AGENDA ITEM 10

##### **Items with financial implications and recommendations**

HAB-S requests travel funds for:

- 2 invited speakers for a ½-day Topic Session on “*Conceptual and numerical models of HAB dynamics*” at PICES-2010,
- 2 invited speakers for a 1-day Workshop and lab demo on the “*New technologies and methods in HAB detection I. HAB species detection*” at PICES-2010,
- a PICES member to attend ICES WGHABD meetings.

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HAB-S requests *ex-officio* membership for:

- Dr. Takafumi Yoshida (NOWPAP CEARAC),
- an ICES HAB Working Group member.

HAB-S recommends that the following be considered for removal due to lack of contribution and activity:

- Canada – Dr. Jennifer Martin,
- Russia – Dr. Gennady Kantakov, Dr. Nina Klochkova.

HAB-S recommends that the following be considered by their countries to be added to HAB-S for their valuable contributions:

- China – Drs. Hao Guo, Jinhui Wang.

HAB-S requests that Canada provide an additional expert to the HAB-S who can report on Canadian HAB data and that Canada provide funds for travel for their HAB-S members to PICES Annual Meetings.

### AGENDA ITEM 11

#### Summaries of the HAB-S Topic Session and Workshop at PICES-2009

Summaries of the MEQ Topic Session (S4) on “*Mitigation of HAB events*” and the MEQ Workshop and laboratory demonstration (W6) on “*Review of selected harmful algae in the PICES region: V. Cyst-forming HAB species*” can be found in the Session Summaries section of the PICES-2009 Annual Report.

#### HAB-S Endnote 1

#### HAB-S participation List

##### Members

William Cochlan (U.S.A.)  
Shigeru Itakura (Japan)  
Hak-Gyoon Kim (Korea, Co-Chairman)  
Weol-Ae Lim (Korea)  
Olga Lukyanova (Russia)  
Tatiana Morozova (Russia)  
Tatiana Orlova (Russia)  
Michail Simokon (Russia)  
Vera Trainer (U.S.A., Co-Chairman)  
Charles Trick (Canada)  
Yasunori Watanabe (Japan)  
Mark Wells (U.S.A.)  
Mingyan Zhu (China)

##### Observers

Donald Anderson (U.S.A.)  
Robin Brown (Canada)  
Alexander Bychkov (PICES)  
Rongshuo Cai (China)  
Hao Guo (China)  
John Keesing (Australia)  
Ruixiang Li (China)  
Monica Lion (IOC)  
Takafumi Yoshida (NOWPAP CEARAC)

#### HAB-S Endnote 2

#### HAB-S meeting agenda

1. Introduction
2. Approval of agenda
3. Country reports
4. FUTURE science program
5. Relations with international organizations

6. PICES Seafood Safety Project
7. GEOHAB Ocean Science Meeting on “*HABs and eutrophication*”
8. *Ex-officio* membership in HAB-S
9. Workshops and meetings at PICES-2010
10. Items with financial implications and recommendations
11. Summaries of the HAB-S Topic Session and Workshop at PICES-2009

### HAB-S Endnote 3

**Proposal for a 1-day MEQ Workshop and lab demonstration on  
“*New technologies and methods in HAB research and monitoring I. HAB species detection*”  
at PICES-2010**

Here we begin a series of workshops and lab demonstrations focusing on new technologies in harmful algal bloom (HAB) research and monitoring. The first workshop in this series will include demonstrations of new methods in organism detection with concentrated information on HAB species. This workshop and integrated demonstrations will include demonstrations and lectures describing equipment and methods from the following list: environmental sampling platform (ESP), FloCam, sandwich hybridization assay (SHA), qPCR, FISH, and in situ sensors including gliders. This series will continue in the future with demonstrations on automated nutrient samplers, modeling, remote sensing, and other techniques.

Co-conveners: Ichiro Imai (Japan) and Vera Trainer (U.S.A.)

Proposed invited speakers to be selected from the following: Chris Scholin, MBARI; Harry Nelson, Fluid Imaging; and Nicole Poulton, Bigelow Labs.

### HAB-S Endnote 4

**Proposal for a ½-day MEQ Topic Session on  
“*Conceptual and numerical models of HAB dynamics*” at PICES-2010**

Each PICES member country has conceptual models of harmful algal bloom dynamics that link the physics, chemistry and biological aspects of bloom development and decay. The biology gives us information on ecosystem structure but also describes elements contributing to success of a particular species. The chemistry focuses on nutrient dynamics, ratios and preferences among species. Physical processes detail cell and nutrient delivery to the coast. While conceptual models are descriptions of HAB dynamics without numbers, numerical models include rate estimates. In theory, each of these would be supported with the same physical, chemical and ecological foundation, overlap with the unique considerations of different water types and second order ecosystem structure. However, these models vary widely between species and among countries. There has been no comprehensive intercomparisons among these conceptual and numerical models to identify their similarities and differences. The focus of this session will be to seek commonalities among models and identify the unique second order aspects needed to describe the distribution and dynamics of HAB in different PICES regions. We encourage modelers and non-modelers alike to submit their papers.

Co-conveners: Dr. Itakura (Japan) and Dr. Cochlan (U.S.A.)

Proposed invited speakers to be selected from the following: Don Anderson, Patrick Gentien, Wolfgang Fennel, Robin Raine (conceptual model), Tamiji Yamamoto (numerical model on nutrient dynamics and *Alexandrium tamarense*)